

Coastal Engineering Technical Note

ATLANTIC COAST WAVE HINDCASTS (PHASE II)

PURPOSE: To inform coastal engineers of the availability of the Waterways Experiment Station (WES) WIS Report 6, "Atlantic Coast Hindcast, Phase II Wave Information," (Corson, et al., 1982) and to provide guidance on its use. Only one copy of the Phase II report was initially distributed to each Corps district and division office because the report was so large (about 1,200 pages).

BACKGROUND: Knowledge of the ocean wave climate is important for planning coastal operations, estimating coastal sediment movement, designing coastal structures, and for other applications. Information on wave parameters such as wave height, wave period, and wave direction over a long period of time is necessary to reliably define the wave climate. In principle, the ideal solution is to install and operate wave gages to collect this information, and this has been done in some locations; but the cost and time constraints usually make this approach unfeasible. When the wave climate has not been defined by gage data (and this will usually be the case), the climate determined by the WIS hindcasts is the single best source of information available to the planner and designer.

WIS ATLANTIC COAST HINDCAST: The WES Wave Information Study (WIS) calculates wave climatology in three phases. Phase I (Corson, et al., 1981) is a numerical hindcast of deepwater wave data from historical surface pressure and wind. Phase II employed a numerical model, similar to the one used in Phase I, with the addition of wave refraction effects and the use of Phase I data as boundary conditions. However, due to the coarseness of the Phase II model grid, detailed refraction analyses were not possible in Phase II. Phase III transforms the Phase II data into shallow water but provides only limited published data summaries. Phases I, II, and III information will be accessible by computer terminal through the Sea-State Engineering Analysis System (SEAS) when it becomes operational. At this time, the Phase I, II, and III data do not include waves generated by tropical storms. Tropical storm waves

will be added to the data base in future years. Future publications by WES will provide similar wave hindcasts for the U.S. Pacific Coast and Gulf Coast. A detailed User's Manual covering SEAS also will be provided by WES.

PHASE II HINDCAST: WIS Report 6 presents wave information for the 33 Atlantic Coast offshore locations shown on Figure 1. The stations range from approximately 25 kilometers to 80 kilometers offshore in water depths of 20 meters or more. These 33 locations have 20 years of hindcast given at 3-hour intervals.

Station	Latitude	Longitude	Depth(m) ¹
1	44.24	67.71	130
5	43.69	68.33	165
9	43.09	69.63	65
13	42.54	70.23	70
16	42.11	69.48	180
17	41.61	69.40	95
19	40.94	71.30	50
21	41.06	69.99	30
23	40.17	73.82	25
25	40.32	72.52	50
27	39.68	73.72	30
28	39.12	74.26	20
30	38.55	74.79	20
32	38.07	74.69	25
33	37.51	75.21	30
35	37.03	75.11	35
37	36.06	74.92	75
38	35.58	74.83	1740
39	35.02	75.34	75
42	34.29	77.04	25
44	34.46	75.85	110
47	33.64	78.13	20
49	33.08	78.62	25
52	32.51	79.10	35
54	31.86	80.15	30
55	31.29	80.62	20
57	30.73	81.08	20
60	29.79	80.88	20
62	29.42	80.21	70
64	28.48	80.02	75
66	27.54	79.84	310
70	26.60	79.67	550
71	26.13	79.58	700

¹Depth estimated from nautical charts.

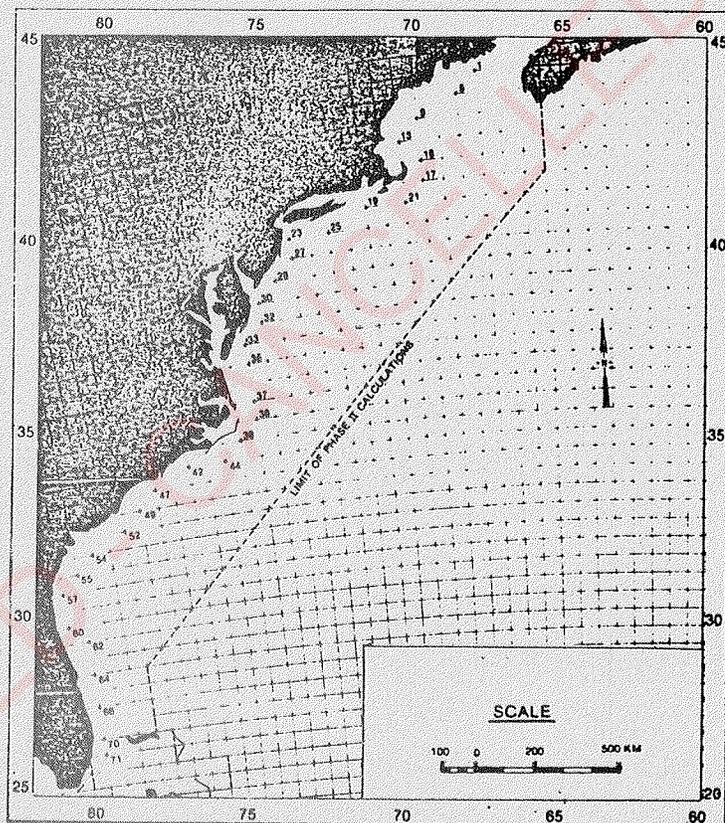


Figure 1: Phase II Station Locations and Approximate Water Depth (in meters)

This information consists of the significant wave height*, and the period and direction of the significant wave. The significant wave height (H_{m0}) represents combined effects of both sea and swell. However, the wave period and direction are given only for the dominant wave condition (swell or sea). Wave period is the period of the spectral peak, while wave direction is the direction from which the waves are approaching.

* In Report 6, the significant wave height, H_s , is four times the standard deviation of the sea surface elevations (often denoted as H_{m0}).

Once the necessary wave parameters have been determined for the given station, wave refraction techniques can be employed to obtain nearshore wave climate at the specific site.

EXAMPLES OF PHASE II PRODUCTS: The wave information of the Phase II hindcast is presented in nine products for each station. Each of these products is briefly discussed below in order to provide a basic understanding of what is included. More details and examples are given in Report 6.

1. Seasonal Percent Occurrence Tables. These tables provide the occurrence percentage for combinations of significant wave height and period. The seasonal azimuth tables give this information for 16 directions for each of 4 seasons. Additionally, tables are provided giving seasonal percentages for all directions. An example is shown in Figure 2 for station 16, season 1 (January through March) and azimuth 180° (waves from the South).

STATION 16		SEASON 1		AZIMUTH=180.0		PERCENT OCCURRENCE(X1000)		TOTAL		
HS(METRES)		T(SECONDS)								
		0.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-LARGER	TOTAL
<0.5	228	318	69	48	34	13	.	.	710	
0.5-1.0	.	934	13	685	1033	263	103	.	2101	
1.0-1.5	.	263	401	334	245	403	90	.	1701	
1.5-2.0	.	.	202	304	245	33	.	.	1113	
2.0-2.5	.	.	207	173	245	88	.	.	773	
2.5-3.0	.	.	27	48	245	41	.	.	635	
3.0-3.5	.	.	6	34	245	27	.	.	434	
3.5-4.0	.	.	.	6	245	13	.	.	143	
4.0-4.5	.	.	.	6	245	6	.	.	123	
4.5-5.0	.	.	.	6	245	.	.	.	47	
5.0+	245	
TOTAL	228	1515	1172	2799	735	1135	193	0		
AVERAGE HS(M) =		1.6		LARGEST HS(M) =		.6.2		AZIMUTH % =		7.9

Figure 2: Example of Seasonal Percent Occurrence Table.

The percentage occurrence for waves with significant wave heights between 2.0 and 2.5 meters with wave periods between 7.0 and 8.9 seconds (from Figure 2) is

$$\frac{373}{1000} = 0.373 \text{ percent.}$$

2. Percent Exceedance Diagrams. These diagrams were constructed from all months in the 20 years of hindcast H_m data. For example (see Figure 3), the significant wave height at station 25 exceeds 5 meters about 0.4 percent of the time.

3. Wave Rose Diagrams. These diagrams present 20 years of hindcast data in eight directional ranges for seasonal and for all months combined. They are intended as visual aids and are not appropriate for detailed analysis. An example is given in Figure 4 (see Report 6 for more explanation).

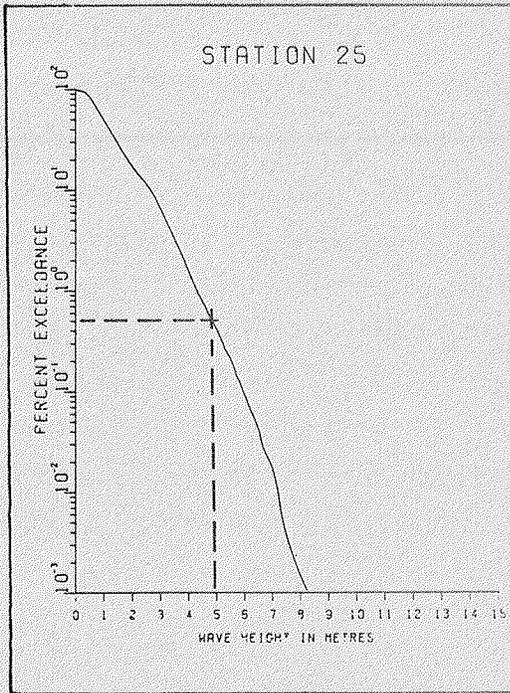


Figure 3: Example of Percent Exceedance Diagram.

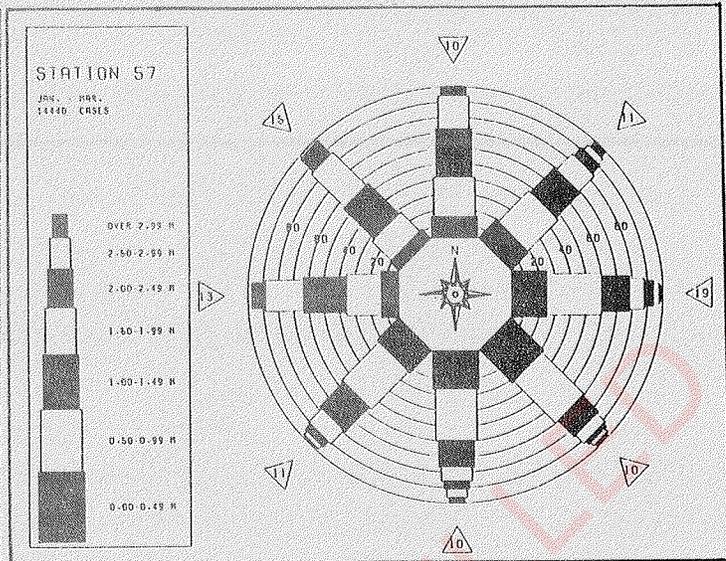


Figure 4: Example of Wave Rose Diagram.

4. Height, Period, Direction Histograms. These histograms are similar to wave rose diagrams. They are intended for use as visual aids and relatively close estimations. They are provided for all stations and were drafted for seasonal and all-months data. Figure 5 gives the histograms for station 28, all-months. Note that about 2/3 of all waves have periods (T_s) between 1 and 4 seconds, just over 1/3 of the significant wave heights (H_s) are between 0.5 and 1.0 meters, and the wave direction (ψ) is somewhat more likely to occur from the 180° to 360° azimuth than the range between 0° and 160°.

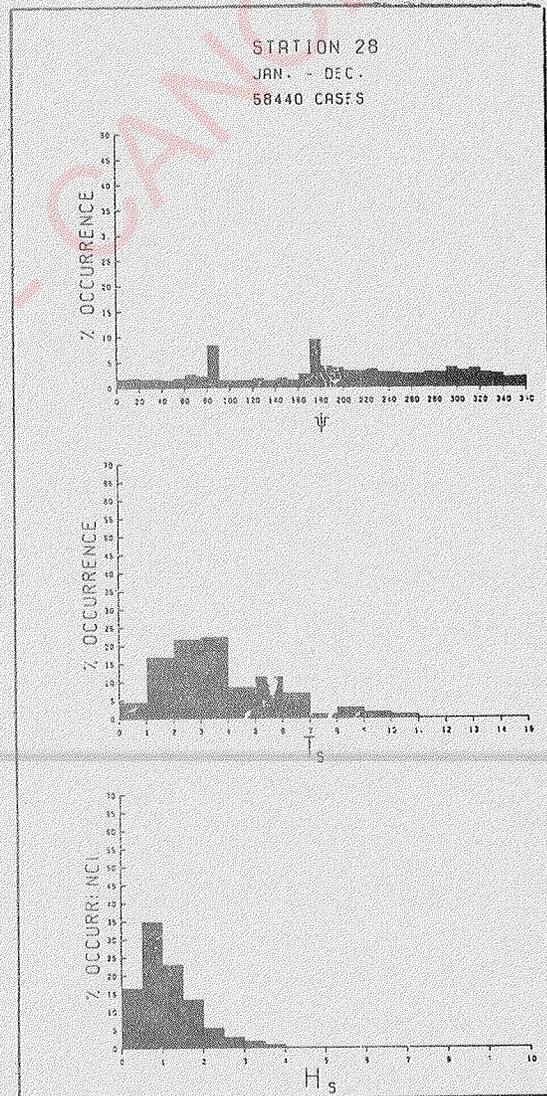


Figure 5: Example of Histogram.

5. Return Period Diagrams. The return period diagrams give extreme wave estimates arising from "northeasters" along the east coast. This information does not include tropical storm conditions, which is frequently a design consideration. Figure 6 is the return period diagram for station 33. An estimate for significant wave height expected to occur once in 10 years is about 7.5 to 8.0 meters.

6. Steepness Diagrams. These diagrams refer to the steepness of the significant wave H_{m0}/L , and are self-explanatory.

An example is shown in Figure 7 (note the presence of both swell and sea waves).

7. Mean and Largest H_s Tables. Two tables, which summarize the mean and largest H_s for each month and year, are provided for each station. The tables can be used as a quick reference in determining gross estimates of wave climate in an area. Additionally, these tables may prove useful in the analysis of past events or of past beach response. Figure 8 provides an example of these tables.

8. Duration Tables. These tables contain H_{m0} duration information for each station. The given values are mean duration (\bar{x}) and maximum duration (m_x) in hours. For the "over" tables (appendix HH), duration is defined as the length of time a wave height persists once the height has been exceeded, and for the "under" table (appendix II), duration is the length of time a wave height persists once the waves become less than the indicated H_{m0} category. For example, from Figure 9, when H_{m0} exceeds 5.0 meters at station 1, it will stay above 5.0 meters for 10 hours on the average and 27 hours at the maximum.

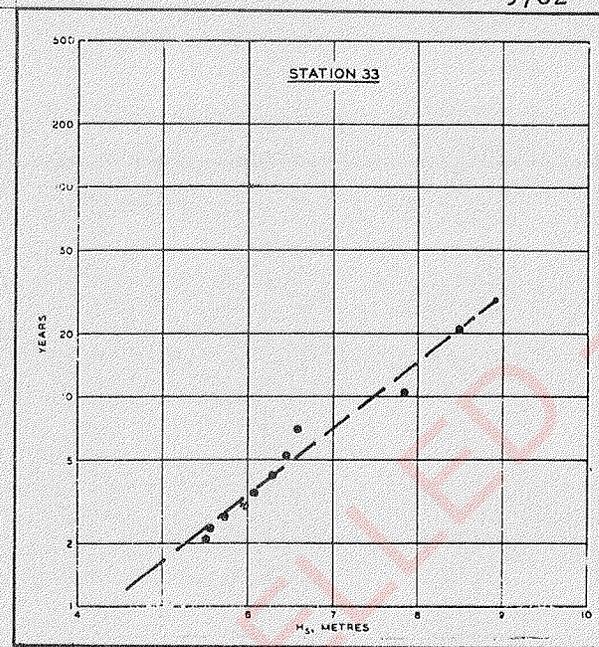


Figure 6: Example of Return Period Diagram.

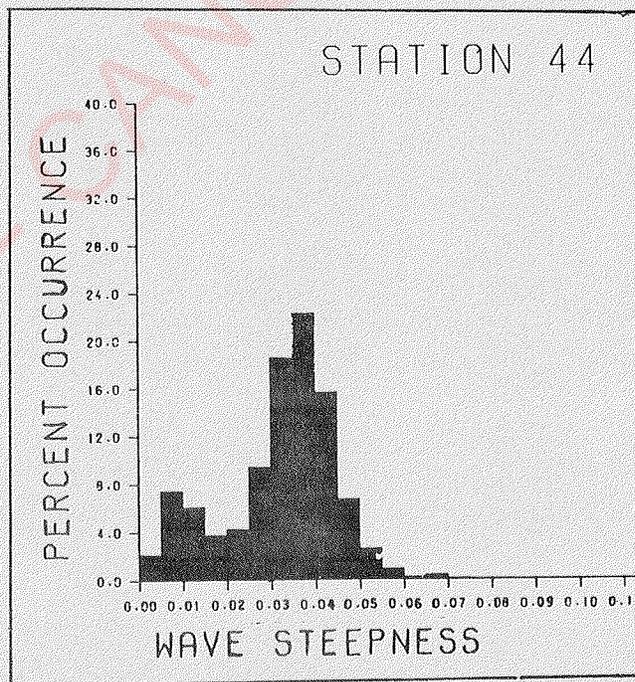


Figure 7: Example of Wave Steepness Diagram.

MEAN HS(METRES) BY MONTH AND YEAR

STATION 19

YEAR	MONTH												MEAN
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1955	2.4	1.7	1.4	1.4	0.9	0.9	0.9	0.8	1.0	1.4	1.4	1.3	1.2
1956	1.4	1.4	1.4	1.3	0.9	0.7	1.0	0.7	0.8	1.1	1.5	2.1	1.4
1957	1.7	2.0	2.0	1.6	0.9	1.1	0.9	0.9	0.9	1.5	1.6	1.5	1.4
1958	1.9	1.6	1.7	1.2	0.7	0.8	0.8	0.7	0.8	1.5	1.8	1.5	1.2
1959	1.6	2.3	1.6	1.4	0.7	1.4	0.9	0.8	0.9	1.2	1.2	1.4	1.3
1960	1.5	1.5	1.4	1.7	1.2	1.0	0.7	0.8	1.4	1.8	1.8	1.4	1.4
1961	1.7	1.6	2.7	1.7	0.6	0.7	0.9	0.9	0.9	1.3	1.8	2.3	1.4
1962	1.5	1.6	1.7	1.2	1.1	0.6	0.8	0.8	1.4	1.1	1.8	1.6	1.3
1963	2.2	1.9	1.7	1.2	1.1	0.5	0.9	0.8	1.2	1.0	1.4	1.5	1.3
1964	1.6	1.5	1.3	0.9	0.6	0.8	0.7	0.9	0.8	1.2	1.5	1.1	1.1
1965	1.4	1.2	1.0	0.9	1.0	0.9	0.4	0.8	1.2	1.0	1.4	1.7	1.1
1966	1.4	1.7	1.7	1.4	1.2	0.7	0.7	0.7	1.2	1.1	1.4	1.5	1.2
1967	1.4	1.7	1.5	1.2	1.0	0.9	0.8	0.8	0.7	1.1	1.5	2.0	1.1
1968	1.4	2.2	1.9	1.4	1.2	0.6	0.7	1.1	0.9	1.1	1.5	1.9	1.5
1969	1.5	1.9	1.4	1.4	1.1	0.9	0.8	0.8	0.8	1.1	1.3	1.8	1.2
1970	1.6	1.6	1.8	1.5	1.3	0.9	1.0	0.9	0.7	1.3	1.3	1.4	1.3
1971	1.6	2.1	1.8	1.1	1.2	1.1	0.7	0.7	1.0	1.4	1.6	1.7	1.3
1972	1.8	1.8	1.7	1.5	1.2	0.9	0.7	0.7	0.8	1.4	2.4	2.8	1.5
1973	1.4	1.9	2.3	1.9	1.0	0.8	0.9	0.8	0.8	0.9	1.6	1.7	1.3
1974	1.5	1.4	1.6	1.6	0.5	0.9	1.1	0.5	0.7	0.9	1.5	2.1	1.2
1975	1.5	1.4	1.6	1.6	0.5	0.9	1.1	0.5	0.7	0.9	1.5	2.1	1.2
MEAN	1.6	1.7	1.7	1.4	1.0	0.9	0.8	0.8	0.9	1.2	1.6	1.7	

LARGEST HS(METRES) BY MONTH AND YEAR

STATION 19

YEAR	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1955	6.1	4.8	4.5	5.3	2.7	2.8	2.8	2.2	5.4	3.9	3.8	4.4
1956	3.7	4.6	4.7	4.5	2.2	3.3	2.0	2.6	2.8	1.1	3.5	4.4
1957	3.9	5.4	5.4	3.7	2.1	2.3	2.0	3.1	2.8	3.9	4.0	4.2
1958	5.5	3.9	4.9	3.2	2.8	2.7	3.3	2.0	1.7	4.5	4.7	5.5
1959	3.9	6.9	4.1	6.2	1.8	3.0	6.2	2.7	4.0	1.7	3.3	4.7
1960	4.6	6.5	4.1	4.0	4.7	3.0	1.6	1.8	6.2	3.6	3.9	4.0
1961	4.2	3.8	7.5	4.8	3.1	2.0	2.9	3.2	3.3	3.8	4.2	7.3
1962	4.9	6.4	4.3	3.6	3.8	2.4	3.5	3.2	4.3	3.9	5.9	4.5
1963	5.8	4.4	3.7	3.6	2.8	2.3	3.4	2.7	3.6	2.6	4.0	3.7
1964	4.4	4.0	3.0	3.3	1.5	3.3	2.0	2.9	1.9	3.7	3.6	3.1
1965	6.5	8.1	2.9	3.1	2.9	3.2	2.4	1.3	2.8	4.4	3.2	4.1
1966	5.9	6.5	4.0	4.0	3.7	3.0	2.0	1.8	3.7	4.9	3.6	4.7
1967	4.0	3.9	6.1	3.3	4.0	2.3	1.3	1.8	1.9	3.2	4.7	5.2
1968	4.2	4.6	4.6	3.2	4.2	1.4	1.7	2.8	3.1	3.3	4.0	6.1
1969	8.1	5.1	3.7	4.4	3.1	1.8	2.7	2.8	1.5	3.4	4.0	4.9
1970	5.3	5.3	4.8	5.6	3.3	1.7	2.7	3.3	1.6	3.4	3.9	3.6
1971	4.3	7.5	4.5	3.4	3.5	4.4	1.6	2.6	5.5	3.6	4.8	5.5
1972	5.8	4.3	5.4	5.4	2.9	1.8	0.7	2.8	1.8	4.9	6.3	4.9
1973	4.2	6.8	6.2	4.5	3.3	3.2	2.2	2.9	3.5	3.1	4.1	5.0
1974	4.9	6.4	5.2	5.1	2.0	2.4	3.1	1.9	3.4	2.9	4.5	5.4
1975	4.9	6.4	5.2	5.1	2.0	2.4	3.1	1.9	3.4	2.9	4.5	5.4

LARGEST HS(METRES) FOR STATION 19 = 9.9

Figure 8: Example of Mean and Largest H_s Table.

Duration of Waves Over a Specified Height

Wave Height Class	Stations																							
	1		5		9		13		16		17		19		21		23							
	x	mx	x	mx	x	mx	x	mx	x	mx	x	mx	x	mx	x	mx	x	mx						
>0.5	66	4182	63	1134	53	1863	45	2019	65	1884	91	2220	89	1938	108	9741	64	1713						
>1.0	33	1731	32	1134	31	1863	29	879	33	1827	41	1014	38	1407	44	1143	29	1080						
>1.5	26	639	26	315	26	510	24	255	28	681	31	522	29	666	33	459	23	426						
>2.0	21	144	22	228	22	150	20	288	24	165	27	321	25	354	28	360	19	138						
>2.5	16	111	19	147	19	147	17	201	20	288	22	216	21	252	24	255	16	144						
>3.0	13	84	13	105	12	102	13	186	14	195	17	195	15	162	19	180	11	69						
>3.5	11	72	12	90	12	99	14	126	15	192	17	192	14	129	18	141	9	45						
>4.0	11	51	13	69	14	87	14	96	16	156	16	117	15	78	18	99	8	30						
>4.5	10	30	11	57	13	66	14	87	16	102	16	93	13	57	17	75	6	21						
>5.0	10	27	10	33	12	57	13	66	14	75	16	72	12	42	15	69	6	15						
>5.5	9	21	12	24	11	42	15	60	15	69	14	63	11	33	14	57	5	9						
>6.0	9	18	10	18	11	33	13	36	13	33	11	36	9	18	13	48	4	6						
>6.5	9	15	10	18	9	15	9	18	13	9	18	8	27	9	15	13	42	---						
>7.0	7	15	8	15	6	12	9	12	9	18	8	12	11	15	5	12	11	30	---					
>7.5	5	9	9	12	9	9	---	---	---	8	12	11	15	5	12	11	30	---						
>8.0	6	9	9	9	8	9	---	---	---	7	9	8	12	12	12	9	15	---						
>8.5	4	6	9	9	6	6	---	---	---	4	6	6	9	9	9	9	15	---						
>9.0	4	6	6	6	---	---	---	---	---	3	3	9	9	9	9	9	9	---						
>9.5	3	3	---	---	---	---	---	---	---	---	---	6	6	6	6	6	6	---						
>10.0	3	3	---	---	---	---	---	---	---	---	---	6	6	---	---	6	6	---						
>10.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	3	---						
>11.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---						

(Continued)

Note: x equals the mean duration in hours for the specified wave height class; mx equals the maximum duration in hours for the specified wave height class.

Figure 9: Portion of Duration Table.

REFERENCES:

CORSON, W. D., RESIO, D. T., BROOKS, R. M., EBERSOLE, B. A., JENSEN, R. E., RAGSDALE, D. S., and TRACY, B. A., "Atlantic Coast Hindcast, Phase II Wave Information," WIS Report 6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, March 1982.

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